Application of scenario-neutral methods to quantify impacts of climate change on water resources in East Africa

*David Macdonald, **Matthew Ascott**, Dan Lapworth, Callist Tindimugaya*

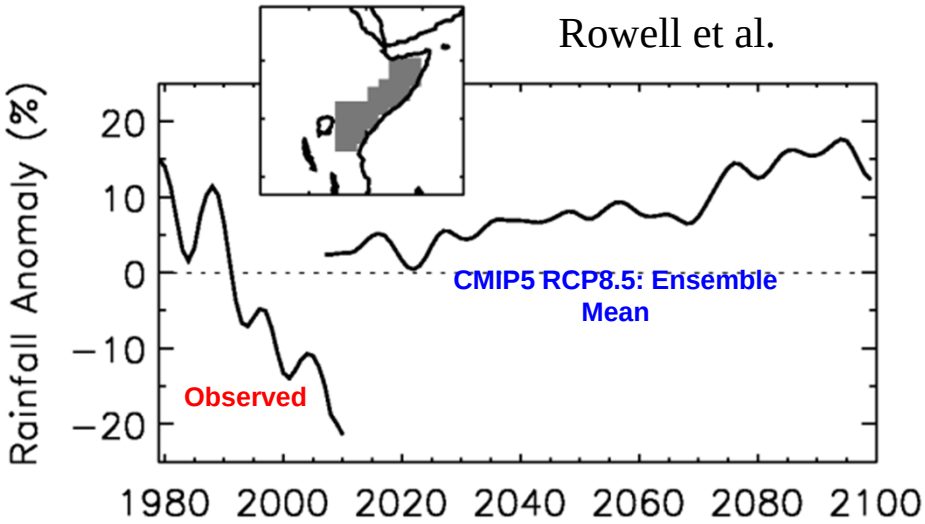
AGU, 14th December 2017

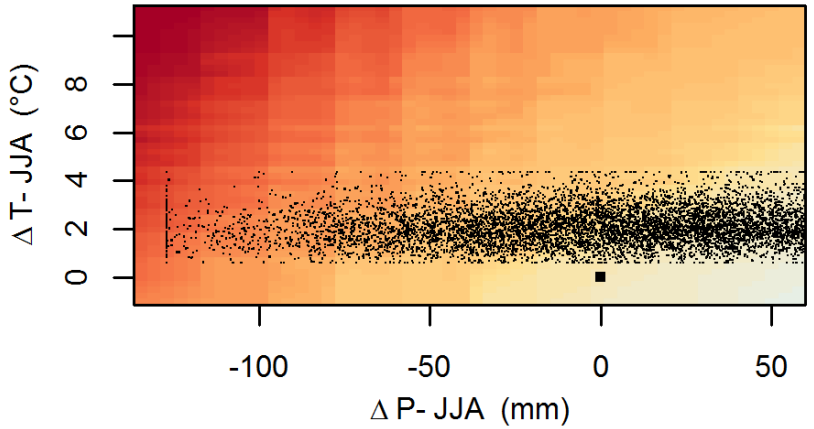
Overview

- Background
- Study area
- Hydrological model development
- Scenario-neutral response surface development
- Next steps
- Conclusions

Background

- High level of uncertainty in climate change & impacts in East Africa
- Water resources planners need new tools to explore potential climate change impacts
- “Scenario-neutral methods” recently developed to explore climate sensitivity
- Initial application of these methods in East Africa

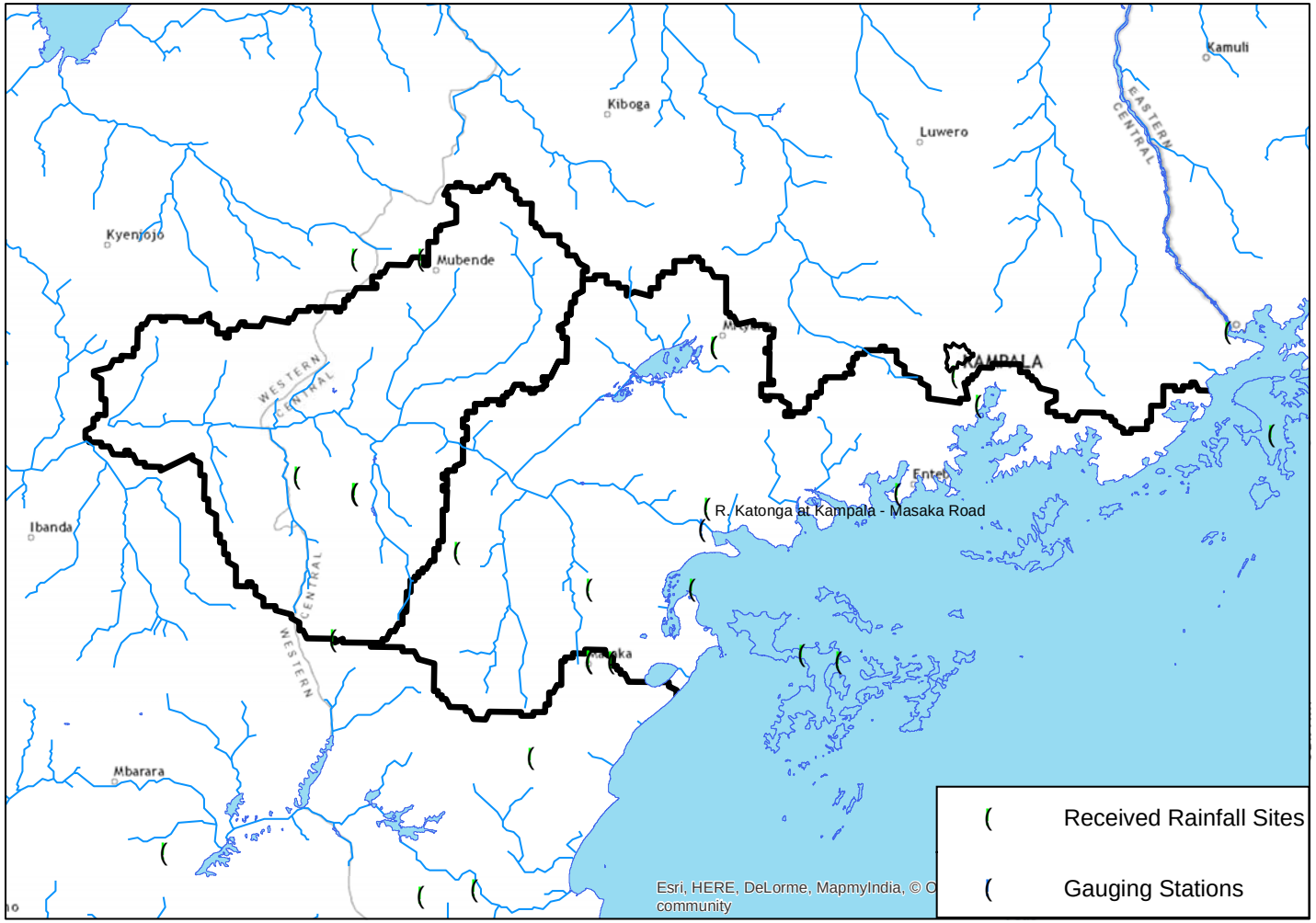


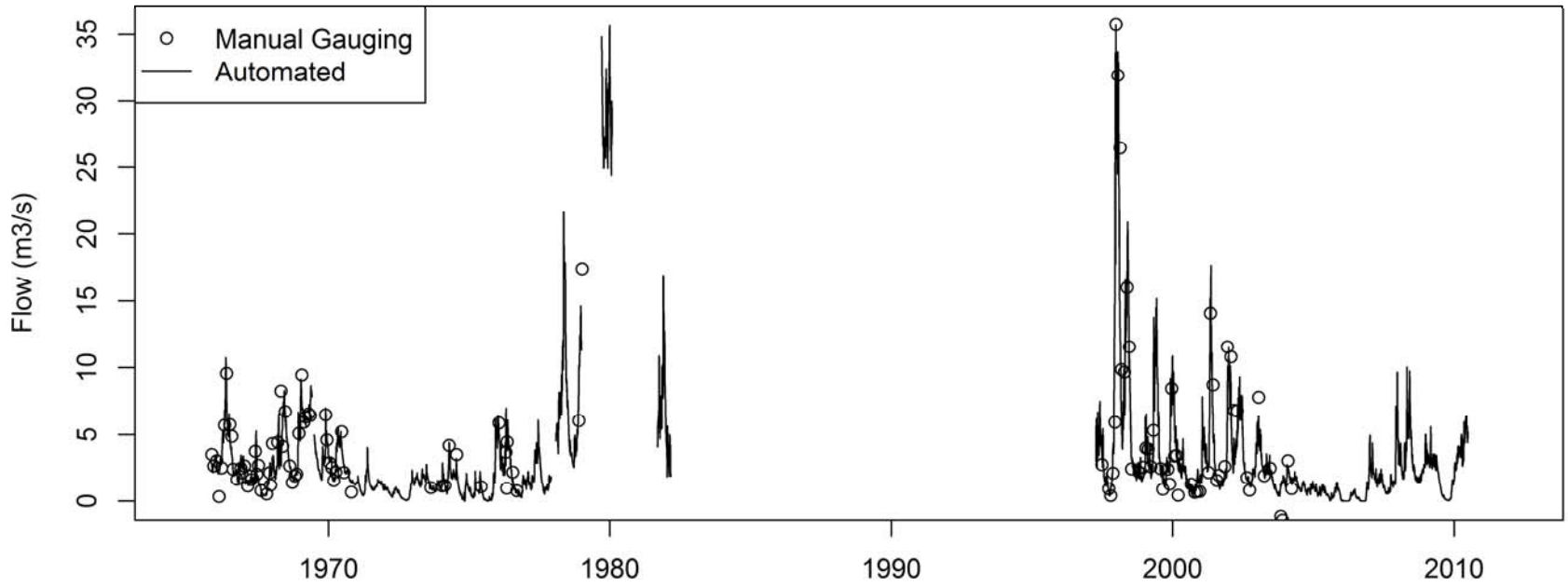


Prudhomme et al.

Study Area

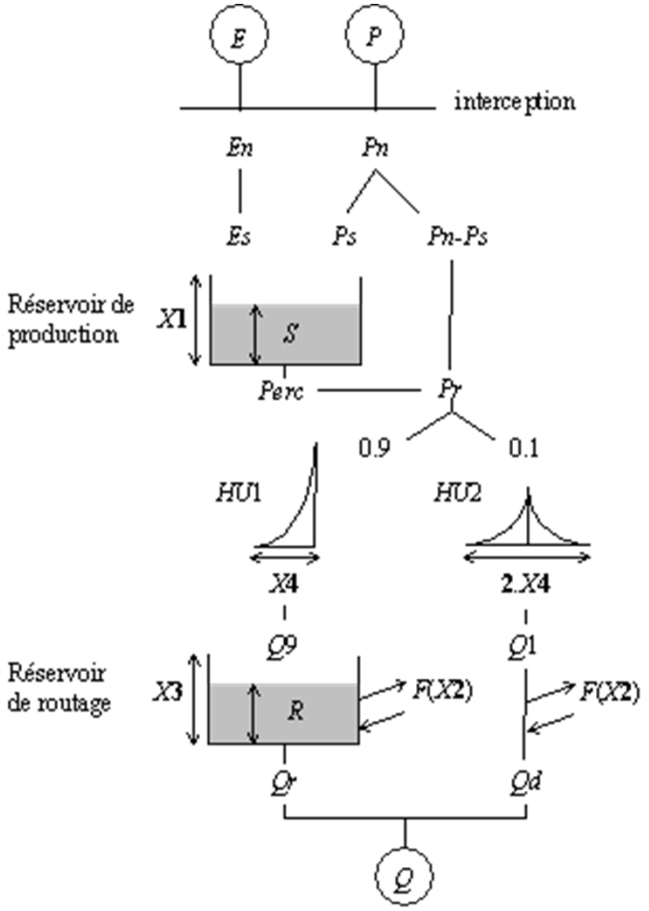
- Katonga Basin, Uganda
- 1 of 6 Water Management Zones in Uganda
- Relatively understudied
- Substantial increases in water demand predicted
- Need by MWE to understand climate change impacts for water resource planning



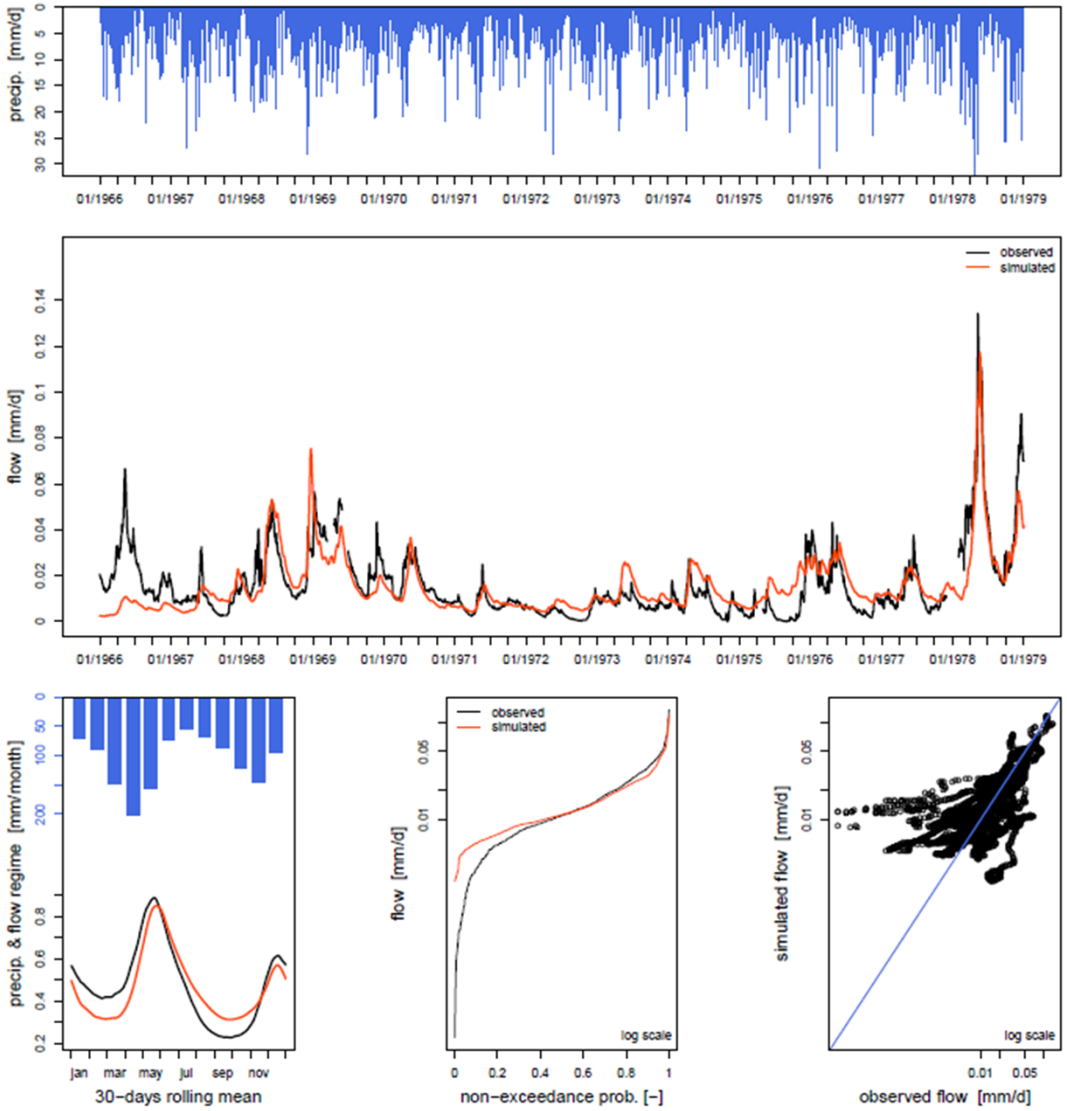


Hydrological Model Development

- Lumped catchment modelling using catchment model GR4J using the AirGR package in R
- Catchment outflow
  - Katonga at Kampala-Masaka Road
  - Flow data for 1966 – 1979 and 1997 – 2010
- Driving data
  - Observed rainfall data provided by MWE/MIDAS
  - Thornthwaite (PET)
- Reasonable calibration (NSE = 0.69)



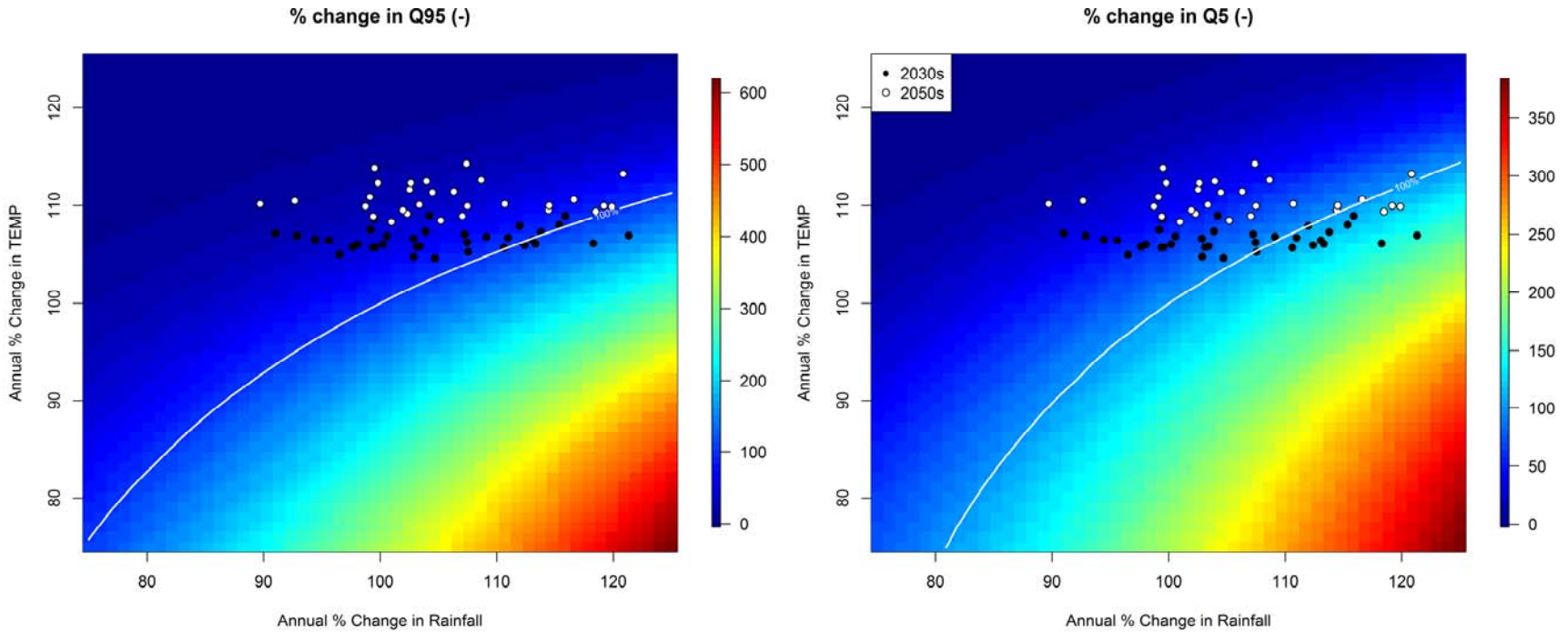
Model Calibration



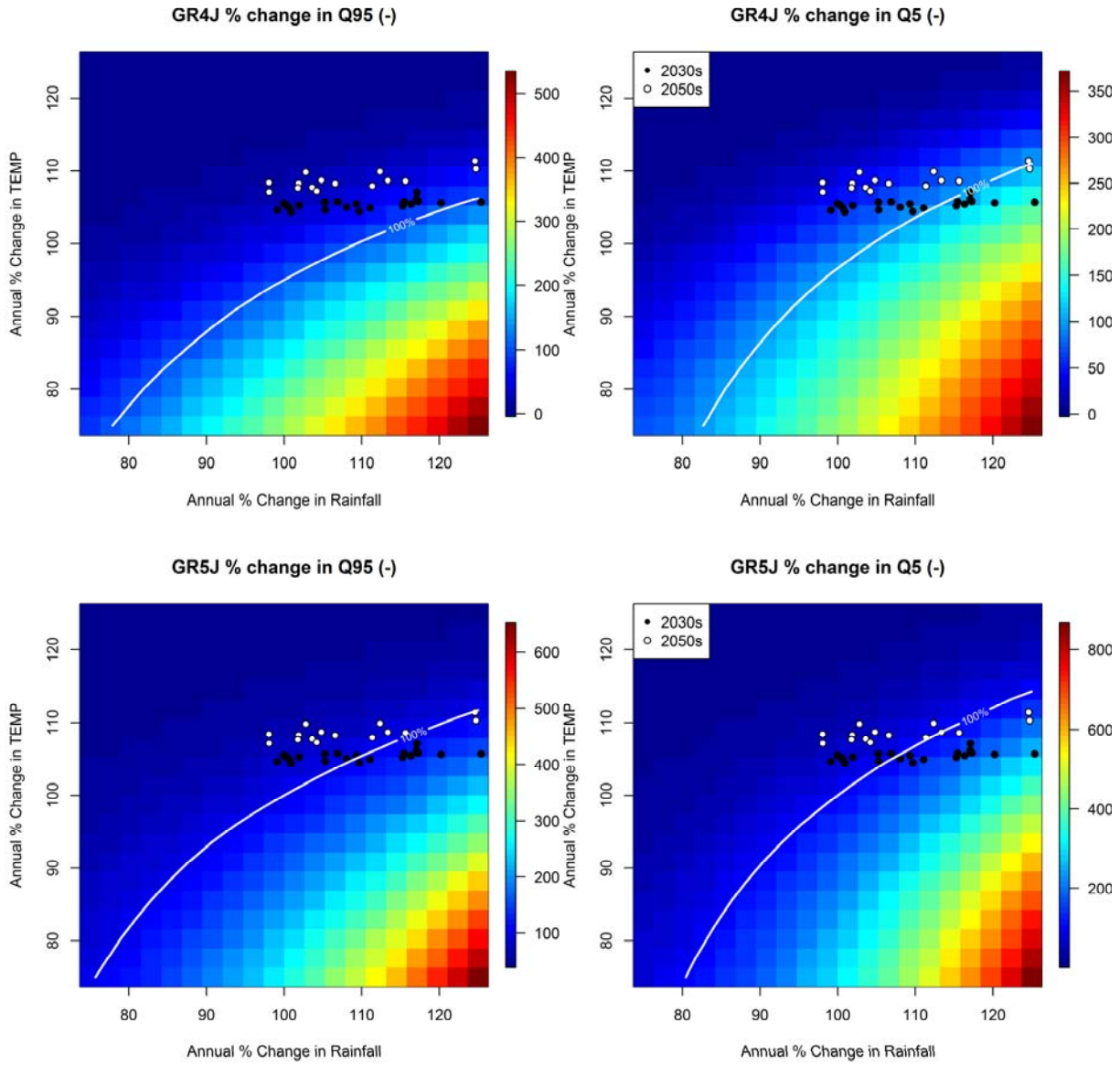
Scenario neutral response surface development

- Consider a wide range of plausible climate futures, beyond climate model outputs
- Parsimonious, quick-to-run model needed
- Develop “response surface” where scenarios are overlain
- Key metrics for stakeholders → Q5, Q95
- Initial work using annual changes
- Exploring impact of different hydrological model structures

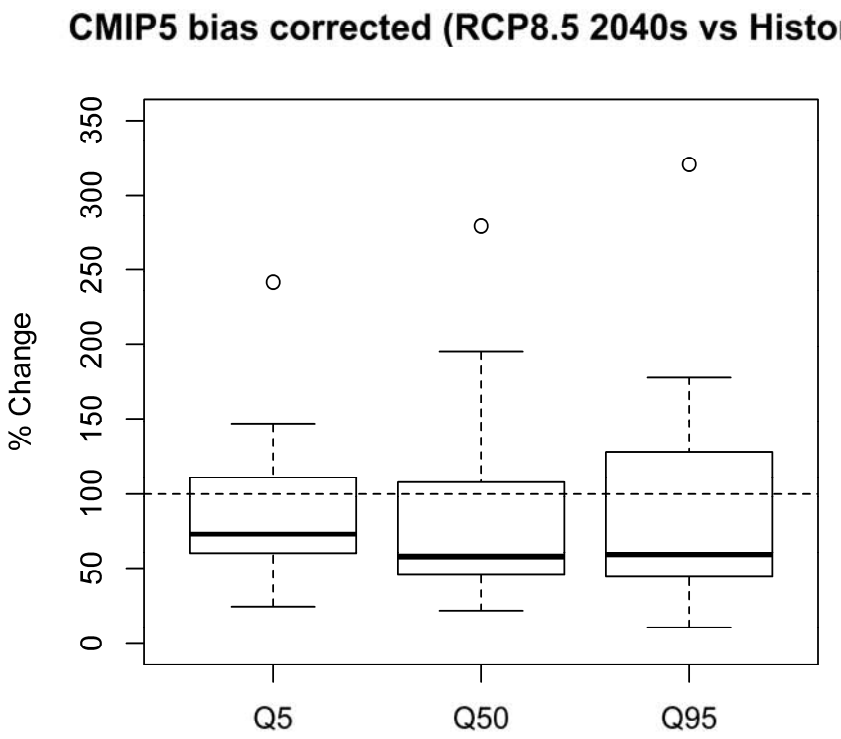
Response Surfaces

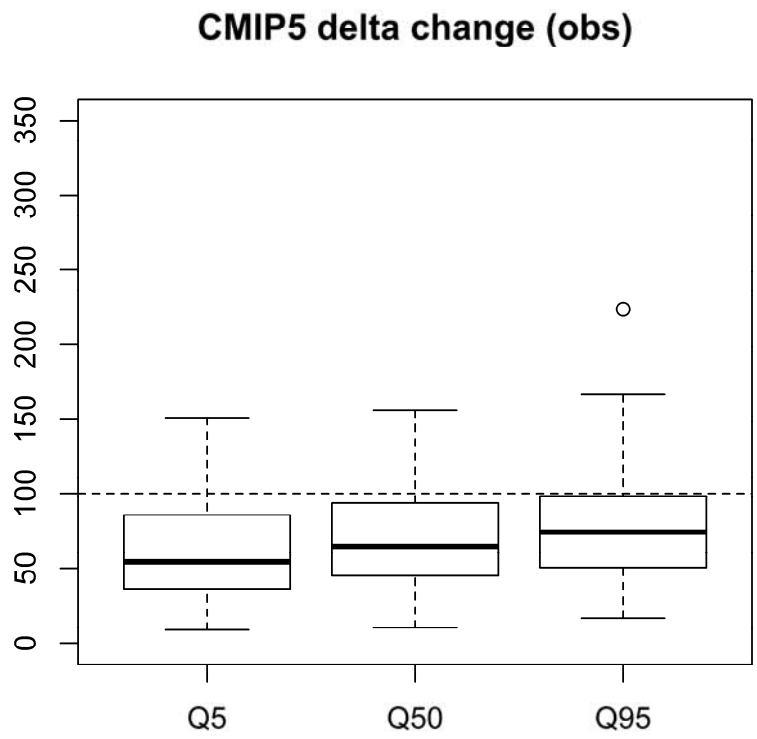


Impact of hydrological model structure



Bias-corrected CMIP5 vs delta change





Next steps

- Computational challenges in application of these methods in East Africa
  - Climate model disagreement
  - Difficult to apply simple models of intra-annual variability
  - Monthly response surface = X^{24} dimension “surface”
- Further work
  - Consider intra-annual variability from a subset of CMIP5 models following model evaluation
  - Application to semidistributed models (e.g. SWAT)
  - Consideration of landuse and socioeconomic changes
  - Other approaches (monthly delta change, weather generator)

Conclusions

- Initial application of scenario-neutral methods to quantify climate change impacts in East Africa
- Response surfaces can give water resource planners an overview of sensitivity of water resource system to future changes
- Hydrological model structure has significant impact on surface
- Computational challenges in application when needing to consider intra-annual variability
  - Further work needed to evaluate CMIP5 in EA

Thank you

Questions

Hydrogeological conceptual model development

- Data collected:
  - 35 constant rate tests, 22 step drawdown tests
  - From Uganda MWE Permitting, across Kampala
- Full pumping test analysis for 5 tests
- Logan method used for others
- Ballpark transmissivity estimates to underpin detailed modelling
  - T_{mean} = 10.2 m2/d
  - T_{min} = 1.7 m2/d
  - T_{max} = 71 m2/d

Hydrogeological conceptual model development